Creation/Evolution

Do "transitional forms" have improved fitness?

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About this issue . . .

Creationists make much of the supposed problems with "transitional forms." Their first charge is that none exist. This has been answered in previous issues of this journal. Their next charge is that, if any transitional forms came into existence, they couldn't possibly advance evolution. Half-formed organs, they argue, could not function and thus would not improve evolutionary "fitness," being theoretically unworkable. Christopher Gregory Weber answers that argument in the lead article of this issue by showing how evolutionary scenarios are, indeed, theoretically workable.

It is important, however, to go beyond theoretical formulations and provide a clear biological example of the creative power of random mutation plus selection in generating evolutionary changes. This is accomplished by Edward E. Max in his article, which begins on page twenty-one. Max shows how the immune response is evolution in miniature.

Also in this issue, we challenge common features of the creationist alternative. John A. Moore shows how the creationist approach is not scientific. Walter F. Rowe applies forensic science and taphonomy to creationist claims about the behavior of animal remains during a flood. And James S. Monroe answers creationist claims for the existence of human artifacts in ancient geologic strata.

Meanwhile, comments on the Brown-Lippard exchange and the second law of thermodynamics debate continue in the letters section.

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A "Transitional Forms" Checklist

Christopher Gregory Weber

Creationists often cite examples of plants and animals with remarkable adaptive features and instincts to demonstrate that such features and instincts could not possibly have evolved gradually, step by step. They argue that these traits would need to be complete and functioning from the very beginning; any half-formed organs and behaviors would be useless at best and lethal at worst, resulting in unsuccessful "transitional forms."

When one looks at the actual evidence, however, one discovers that these traits are not as difficult to explain as creationists have led people to believe. There exist quite workable scenarios for how some of the most complex adaptive features and instincts most likely evolved.

To produce an effective response to the creationist charge that evolutionary scenarios are unworkable, I recommend that each creationist example be run through the following checklist. By this means, one can often uncover a simple, straightforward explanation that creationists simply have overlooked.

1. Could the current use of a given organ merely be a side effect of an earlier use?
2. Is it possible that a parasite evolved to fit the host rather than vice versa?
3. Could the basic brain mechanism that generates a behavior be much simpler than we have suspected?
4. Are intermediate forms known today?
5. Could an organism evolve a new trait to supplement an old trait and later drop the old trait as the new one was perfected?
6. Could individual pieces of a complex behavior pattern have been beneficial if they had evolved alone?

Let's cover each of these in detail.

Chris Weber, one of the founders of Creation/Evolution, *is a computer programmer and amateur geologist who has followed the creation-evolution controversy for over seventeen years.*

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1. Could the current use of a given organ merely be a side effect of an earlier use? Perhaps the organ had originally evolved straightforwardly for one use and was later turned to a totally different use.

For example, it has been proposed that feathers originally evolved to insulate dinosaurs from the cold. If Desmond (1977) is correct, many dinosaurs were warm-blooded, and so such insulation would be useful. During Jurassic times, small feathered coelurosaurian dinosaurs took to running on two legs to chase their prey. Those that hopped over ditches in their pursuit would benefit if the feathers on their forelimbs evolved to give them some lift as they hopped. In this way, one group of coelurosaurian dinosaurs evolved flight and became birds.

Another example is the nudibranch sea slug which is able to eat sea anemones because it has an enzyme that keeps the sea anemones' stinging cells (nematocysts) from firing their poison. Such an enzyme by itself would be helpful to any ocean animal that lives near sea anemones, because sea anemones capture their food and defend themselves from most enemies by stinging the intruders with their nematocysts. However, the sea slug does even better than this. When it digests its sea anemone dinner, the nematocysts are not digested and are moved through ciliated passages from the digestive tract to the fronds on the sea slug's back. Thus, the sea slug keeps the nematocysts intact and puts them to use for its own defense.

Creationists maintain that this adaptation could not have evolved piecemeal, but they have not pondered the problem thoroughly. Originally, the sea slug probably evolved extensions of its gut to bring digested food that much closer to the cells it was supposed to nourish. The sea slug also evolved an intestinal enzyme to keep the nematocysts from exploding or being digested; that way the poison would not be released to affect it. Later on, once the extensions of the gut got as far back as the sea slug's skin, some of the nematocysts would find their way to the surface of the back where they could begin to act as a defense. The frondlike growths on the animal's back and the cilia in the special passages would then be later refinements. Thus, the nudibranch sea slug is not the difficulty that the creationists say it is.

2. Is it possible that a parasite evolved to fit the host rather than vice versa? Creationists often argue that evolution cannot explain why certain host species lovingly take care of certain parasites to their own detriment. However, in all their examples the parasite did the evolving, not the host.

For example, the cuckoo often lays its eggs in the nests of warblers. When the baby cuckoos hatch, the parent warblers take care of the cuckoos as if they were their own hatchlings. The baby cuckoos, which are much stronger than the warbler chicks and often hatch earlier, heave the eggs and hatchlings of their foster parents out of the nest and hog all the food for themselves. Obviously, the cuckoos evolved traits to trigger the parental instincts mechanisms in the brains of the warblers; the warblers did *not* evolve instincts to take care of cuckoos.

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3. Could the basic brain mechanism that generates a behavior be much simpler than we have suspected? Creationists say that certain instincts are far too complex to have evolved piecemeal, but the basic mechanism underlying the behavior is often quite simple.

For instance, some solitary wasps paralyze caterpillars with their stings and then store them in their nests to serve as food for their offspring when their eggs hatch. Creationist Evan Shute (1961) marvels that the wasp grubs avoid eating the vital organs of the caterpillar so that their food supply will stay alive and not spoil. He claims that mere evolution could not have put such an exact knowledge of caterpillar anatomy into the wasps' heads. But the grubs don't have to know caterpillar anatomy if they have the much simpler instinct to eat only those parts of the caterpillar that smell a certain way and if it so happens that the parts that have this distinctive smell are not vital organs.

As another example, Robert Kofahl and Kelly Seagraves (1979) argue that migratory birds are born with a map of the stars in their heads and navigate by the stars during their migrations. Their sources, E. G. F. Sauer (1958) and Stephen Emlen (1975), show that birds use constellations to determine which way is north. However, the birds' mechanism is much simpler and far more general than having an inborn map in their heads. Emlen points out that baby indigo buntings that never see the sky grow up not knowing in which direction to migrate. His planetarium experiments show that the baby birds watch the stars at night rotate around the Pole Star, and from this they learn the main constellations that show which way is north. It stands to reason that the birds have to learn the stars from scratch with each generation, for the earth wobbles on its axis and takes 26,000 years to complete one wobble. These wobbles make the axis of the earth inscribe a circle in the heavens that is forty-seven degrees across. Hence, the stars in the sky were positioned quite differently 4,000 years ago. If the birds were born with maps in their heads of the stars in the heavens today, as Kofahl and Seagraves maintain, then, in the days of Abraham, 4,000 years ago, when the current Pole Star was about 23.5 degrees away from the point over the pole, the poor birds trying to navigate by the stars as they migrated would have first veered 23.5 degrees too far to the left twelve hours later in the day. It's a good thing for the birds that each generation has to learn the stars from scratch!

4. Are intermediate forms known today? Often creationists say they can't understand how an intermediate form could possibly survive—while ignoring the fact that intermediate forms are surviving quite well in our own day. The more primitive forms manage to survive beside their more advanced cousins because they live in different ecological niches and, hence, do not compete.

For example, creationists insist that the social behavior of bees and wasps could not have evolved in any gradual manner. But any standard encyclopedia will describe a number of modern intermediate forms that span the gap from solitary bees and

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wasps all the way to complex colonies.

As another example, creationists say there is no conceivable way the vertebrate eye (or the mollusk eye) could have evolved in gradual steps. However, George Gaylord Simpson, in his book *The Meaning of Evolution*, shows that different species of modern snail have every intermediate form of eye—from a light-sensitive spot to a full lens-and-retina eye.

5. Could an organism evolve a new trait to supplement an old trait and later drop the old trait as the new one was perfected? Perhaps a trait we observe at a particular time is just evolving and is far from perfected, although helpful, while the organism is relying primarily upon the older trait. Later on, when the new trait is perfected, the old trait can be dropped.

For instance, the euglena is a protozoan that obtains its food both by photosynthesizing with its chloroplasts like a plant and also by capturing and eating other one-celled organisms like an animal. However, its close relative, the astasia, lacks chloroplasts and seems to do well just capturing other one-celled organisms. Probably the original photosynthesizing ancestor of the euglena obtained an advantage by evolving the ability to ingest organisms but relied mainly upon its photosynthesizing ability until this new ingestion mechanism was perfected. Later on, some food-ingesting euglenalike organisms entered an ecological niche where photosynthesis was not necessary; so they lost their chloroplasts by mutation and natural selection and became the astasia.

As another example, female mosquitos of most modern species need to eat mammal blood in order to make their eggs mature, but female mosquitos of other species can get by on nectar and fruit juices, though they will eat mammal blood if they can get it. Probably the ancestral mosquitos, which evolved from flylike ancestors, ate nectar and fruit juices exclusively. Later on, they evolved bloodsucking as a helpful but not absolutely necessary way of obtaining the needed nutrition in an efficient concentrated form. Probably early mosquitos relied mainly upon more reliably obtainable (if not nearly so concentrated) plant foods but drank blood from the wounds of animals whenever wounded animals were available. Later on, when the bloodsucking mechanism became more efficient and complete, some mosquitos found themselves in ecological niches where there was a steady supply of rich mammal blood and so lost their ability to obtain their nourishment through less efficient ways.

6. Could individual pieces of a complex behavior pattern have been beneficial if they had evolved alone? Creationists often jump to the conclusion that a complex behavior pattern could not have evolved piece by piece, when only a little thought suffices to show that it could—with each new piece of the behavior being functional and useful from its inception.

For instance, the clownfish lives in sea anemones, shares its food with them, and derives protection from them. The nematocysts of the anemone do not bother

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the clownfish, so the two creatures get along splendidly. Is it possible to explain how the two creatures evolved step by step so that they would get along with each other? Perhaps the proto-clownfish, which originally did not live in sea anemones, evolved an enzyme to prevent the nematocysts of sea anemones from going off because clownfish with such an enzyme would become meals for sea anemones less often. Later still, the proto-clownfish (stage two) evolved an instinct to hang around sea anemones because the sea anemone would eat the proto-clownfish's enemies and not the proto-clownfish. Later still, the clownfish evolved the instinct to feed the sea anemone because by helping the sea anemone it was indirectly helping itself.

As another example, the bull's horn acacia trees in Central and South America grow hollow hornlike growths and food nubbins to house and feed stinging ants. In return, the ants protect the trees from encroaching vines and hungry insects. In this case, the trees and the ants evolved to benefit each other. At first, the ants simply attacked any insects they ran across, either to eat them or otherwise destroy them as a threat to the colony. Since the prey insects tended to defoliate trees, the trees in the neighborhood would benefit any time the ants came around to eat the local tree-eating insects. Therefore, the proto-bull's horn acacia evolved traits that attracted the ants by providing food and shelter for them. In return, the ants evolved instincts to hang around bull's horn acacias because they got free room and board in return for their protection of the plant.

As usual, creationists tend to create mysteries where there are no mysteries. This checklist helps remove the mystery from most creationist examples of complex traits that supposedly could not have evolved step by step. I do not propose that what has been offered here is the only way to explain the evolution of these traits. I have preferred adaptive scenarios, and I recognize their speculative nature. My reason for providing them is to answer the speculative *creationist* claim that evolutionary change *cannot* occur. And I answer it using evidence readily available in the natural world.

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Is "Creation Science" Scientific?

John A. Moore

It is self-evident that whether or not a particular intellectual endeavor is labeled science depends upon how one defines *science*. The term has both a general and a restricted use. In the restricted usage, *science* means the natural sciences, such as astronomy, physics, chemistry, biology, geology, and parts of psychology. The general use finds the natural sciences lumped together with domestic science, Christian Science, political science, social science, cosmetological science, and military science. *Science* in the general sense is used legitimately to denote a systematized body of knowledge or illegitimately in an attempt to increase the respectability or acceptability of a field of endeavor.

I believe that it is fairly obvious that creationists label their point of view *creation science* in order to gain respect and acceptance. They have had some measure of success—not surprising since obfuscation has long been recognized as a useful political and social device. Words can be conscripted for uses far removed from their acceptable meanings. Thus, we note that, of the former two halves of Germany, the one that carried the name German Democratic Republic was the less democratic one. In a similar manner, the people seem to be a minor force in nations that call themselves *people's republics*. The older generation will remember the extraordinarily effective technique of the "big lie." There is a discouragingly large proportion of the population that delegates the matter of thinking to others and, hence, tends to believe what it is told and almost always believes what it reads.

Creationists in the United States are engaged in a similar muddying of the waters. This becomes obvious when they claim that creationism is just as scientific as evolution. Such use is so patently fraudulent that the creationists must be following in the footsteps of Humpty Dumpty who maintained, "When I use a word, it means just what I choose it to mean."

So, it becomes necessary to ascertain what is the essence of a natural science and how it differs from other sorts of knowledge. We can then decide to what extent the creationists can claim to be creation *scientists*. Since above all else science is

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a way of knowing, we must consider the methods employed in reaching acceptable levels of understanding.

Science

First, what is the domain of the natural sciences? They are, as the name implies, concerned with the phenomena of the natural world—that is, the cosmos, our world, and its living creatures. But surely, one asks, isn't that the domain of all inquiry? Theologians, poets, social scientists, political scientists—as well as natural scientists—are concerned, at least in part, with the phenomena of the natural world. There is a basic difference, however. Strictly speaking, the natural scientists study the phenomena of nature to discover regularities and relationships that do not involve human hopes, aspirations, biases, standards, or perspectives. The medieval writer viewed animals in terms of human or religious characteristics. The lion stood as a symbol of courage; the dog, loyalty; and the ox, strength. The scientist of today tries to deal with the lion in terms of what it is to be a lion—its structure, behavior, relationship to other animals, and so on.

Although the natural sciences are vital for an understanding of so much that human beings are and do, its insights are of greatest use when couched in nature's terms. For the scientist, the heart beats because of stimulation by the pacemaker set in the wall of the right atrium. We stay alive because the heart beats; the heart does not beat to keep us alive. Just imagine the vastly different studies that would engage two scholars: one trying to understand the heart in terms of muscles, nerves, hormones, and various sorts of physiological phenomena; the other with a research scenario based upon the premise that the heart beats in order to keep us alive. One approach leads to the sciences; the other to the humanities. But who of us will not confess that the most important thing about the heart is that it *is* beating to keep us alive.

All work in the natural sciences consists of trying to understand natural events in terms of what they are—not as anthropocentric concepts. Above all else, this means excluding supernatural phenomena and explanations. It is easy for the scientist to exclude supernatural phenomena since, by definition, they are above nature and above the scientist's ability to detect and manipulate. At times, it has been difficult for natural scientists to exclude supernatural explanations for natural events, yet this must be done scrupulously—again, because there would be no way for a natural scientist to test a hypothesis based upon supernatural notions. It may be comforting to many to think of a deity guiding the motions of heavenly bodies, but it is the task of the astronomer to describe their movements in terms of what can be learned of the movements of bodies and their relations to one another in the laboratory. It may be comforting to think of a deity watching over our every heart beat, but most individuals, if the beating is not quite right, seek the advice of a cardiologist

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rather than offer a slain lamb on an ancient altar. Experience suggests the greater efficiency of a visit to the cardiologist.

Second, the natural sciences start with a question about some phenomenon of nature. Science, most certainly, is not the random collection of data relating to the natural world. One does not count or measure the grains of sand on the beach and contribute to the corpus of science. If one counts or measures the grains of sand, it is to answer some specific question: the nature of erosion, the force of the waves, the hardness of different minerals, or the fracture patterns of rocks. One assembles data to enhance understanding. We gain understanding of a natural phenomenon when we can relate it to what we already know or believe we know. The collection of data must be purposeful. Long ago, Charles Darwin expressed this idea when he said, "How odd it is that anyone should not see that all observation must be for or against some view if it is to be of any service" (Darwin, 1903:195).

Third, the data that are used to enhance our understanding of the natural world come solely from observations and experiments on natural phenomena. The data must be collected in an unbiased manner—the goal being to understand a phenomenon, not to prove a point of view based upon what we might prefer to be the explanation.

Fourth, the data from observation and experiment are molded into conceptual schemes that provide explanatory hypotheses for the natural phenomenon being studied. One of the main sources of pride in being a scientist comes from the ability to unite seemingly disparate data into a unified conceptual scheme. Herein lies much of the originality, inspiration, serendipity, and reward.

So, we begin with a puzzle about the natural world. We gather information relating to the puzzle and then devise a hypothesis to explain the puzzle. The next step is one of the most distinctive in the natural sciences, and its rigorous application allows us to make some of the most certain statements that can be made in any field of knowledge.

Fifth, the validity of a hypothesis can be measured by testing the validity of deductions made from the hypothesis. One plays an intellectual game. If the hypothesis is valid, various other statements—deductions—must also be valid. Thus, if one proposes the hypothesis that there is circulation, with blood flowing from the heart through arteries and returning to the heart via veins, then one of two things (deductions) must be true: either there are connections between the arteries and the veins through which the blood can flow from one to the other, or there must be a destruction of arterial blood in the tissues and the production there of new blood that enters the veins. Observations with primitive microscopes revealed the existence of capillary connections between arteries and veins but no evidence for the massive destruction of the arterial blood and the production of new venous blood. So, with these observations and other observations and experiments, the hypothesis of the circulation of the blood was shown to be valid beyond a reasonable doubt.

The testing of deductions allows us to show that the hypothesis is either prob-

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ably incorrect or probably correct. This is part of the self-correcting nature of science which makes it such a powerful device for adding to knowledge. Scientific procedures, if properly used, allow us to know whether or not we are on the right track. When a hypothesis has been tested rigorously and not invalidated, we say it is "true." But being "true" in science is not a final statement; it merely means that it is true beyond a reasonable doubt. Or, expressed differently, the hypothesis represents the most accurate statement that can be made at that time. It would be foolish not to recognize that some scientific statements are true for all intents and purposes—our blood does circulate, just as William Harvey suspected it might.

Sixth, we must emphasize the universality of scientific statements. In the case of recurring and repeatable phenomena, what is true today must be true tomorrow and, by inference, was true yesterday. And there must be a geographic universality: what is discovered in a laboratory in the United States must be discoverable in Japan, France, and Costa Rica. By extension, this means that any scientist with the appropriate apparatus and ability must be able to repeat the observations and experiments of others and obtain similar data. Thus, for this class of phenomena, place, person, and time become unimportant.

There is another class of natural phenomena: those which do not recur, at least in the same manner, and which are not repeatable. Biology, geology, and astronomy provide examples. There are many unique events which can happen only once and, hence, cannot be repeated. You are such an event. You began life as a single cell and, after an awesome embryology, became what you are today. One cannot test hypotheses today about what you were doing at the age of two weeks after fertilization. Nevertheless, it is assumed in biology that observations of other embryos will reveal the general features of development and that, for the most part, your specific development will be essentially the same as all the others. This is an extension of universality. It is assumed that all individuals of our species will have undergone the same general pattern of development. It need not be exact. If, for example, an individual has only five fingers and five toes, that will represent a special and abnormal type of development, as most members of our species have ten of each.

All of this is part of a fundamental premise of the natural sciences: the phenomena of nature can be described by rules, and these rules are discoverable. If we mix the gases oxygen and hydrogen in the presence of a flame or spark, there will be an explosion and water will be formed. If we repeat this experiment under the same conditions, identical results will be observed. If we study the reaction in detail, we will find that two atoms of hydrogen will have combined with one atom of oxygen. Repetition of this experiment will show the same result. Thus, scientists have come to accept that many aspects of nature can be described in rigorous, invariant terms. A given cause has a predictable effect. If *A*, then *B*. We accept this in science, not as a matter of faith but because experience shows such to be the case.

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Not all natural phenomena can be described or predicted with mathematical rigor. The relation between volume, temperature, and pressure of gases can be described precisely. However, this does not mean that the behavior of each and every molecule in the gas can be predicted. The behavior of an individual molecule can be described best as *random*. Yet, the randomness of the behavior of the myriad individual molecules results in the predictable behavior of the population of molecules.

The time of your death cannot be predicted with mathematical precision. There is no way to be sure of the drunken driver as you cross the street, of a pandemic of virulent influenza, or of the birds sucked into the jet engines of an airplane. You are like the individual molecules of a gas. Yet, enough can be said about the average life span of a population of individuals to permit insurance companies to remain solvent and their policies affordable.

All in nature is not chaos. That is why we need scientists as well as poets and priests.

The seventh characteristic of science is also of great importance. No critical observation or experiment is accepted as part of science until it has been verified by one or more scientists in other laboratories or natural situations. This requirement of verification does much to reduce errors that may be the consequence of bias, carelessness, dishonesty, entrepreneurship, inadequate apparatus, inadequate samples, or inadequate brains.

Therefore, it is *verified* data and ideas—not just data and ideas—that become part of the body of science. Darwin is remembered not for what he said but for what he said that was verified. We have some splendid examples in his case of both success and failure. His views on many features of evolutionary biology have stood the test of decades remarkably well, even though most have been modified slightly or substantially. The point is not that he was correct in details but that he pointed scientists toward approaches that have vastly increased our understanding of the natural world. It does neither Darwin's reputation nor science any service to maintain the inerrancy of his views. He remains a pioneer and intellectual giant in the field of evolutionary biology.

On the other hand, Darwin the geneticist was rejected long ago and, today, is remembered mainly by historians of science. His most voluminous work, *The Variation of Animals and Plants Under Domestication* (1868), was an attempt to understand the fundamental nature of inheritance. Such an understanding was essential if his hypothesis of evolutionary change were to be firmly based. He failed in his attempt to formulate rules for and to understand the physical basis of inheritance. The best he could do was to propose a vague concept of gemmules produced by all the microscopic structures of the body. These gemmules were thought to circulate throughout the tissues and enter the eggs and sperm randomly.

Evolutionary biology had to wait a half-century after Darwin in order to understand the nature of the genetic material—the material basis of evolutionary change.

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Darwin's theory of pangenesis was weighed and found wanting. Failing verification, it passed from the field of science.

The eighth, and last, characteristic of science that I will list is science's ability to progress, with each progression regarded as an improvement over what was before. The data base of science improves both quantitatively, as observations increase, and qualitatively, with the improved skills of the scientists, the availability of better equipment, and our learning to ask better questions. This is especially true in the biological and geological sciences, in which the complexity of living creatures and the earth's crust makes it more difficult to formulate rigorous and elegant conceptual schemes.

There is no aspect of evolutionary biology that is not being actively studied and slowly changed. That being the case, the evolutionary biology of today is better than it was yesterday. Contrast this with monuments of creativity in the humanities. Is the music, sculpture, painting, poetry, or prose of today better than that of yesterday? In each period of our cultural past, there were outstanding products of the mind and hand. One cannot say which was better, since the criteria of quality reside in the subjective soul. Not so with science. The science of today is better than the science of yesterday because it provides conceptual schemes that account better for the phenomena of the natural world.

Therefore, we may characterize science as an activity of search and discovery in the natural world and the formulation in naturalistic terms of explanatory hypotheses. Ideally, its statements are objective, impersonal, empirical, rigorous, and honest. However, as science is being done by human beings, it is subject to periodic failure in one or more of these characteristics. Nevertheless, it has powerful devices for verification and self-correction with the consequence that its statements become ever more probable, ever more inclusive, and ever more illuminating. Science renounces a goal of final truth and seeks only to say what seems most probable at the time—most probable on the basis of verifiable information and testable conceptual schemes.

Creationism

We can develop the argument that creationism is *not* science by looking at what creationists do in light of the foregoing eight characteristics of science. First, it must be recognized that there are creationists of many stripes, so when I refer to what creationists do and say I am basing my observations on the activities of the most visible and vociferous—such as the members of the Institute for Creation Research and similar organizations.

First, let's examine the domain of creationist activity. One tends to think of natural scientists as collecting data in field, laboratory, or sky. Then the natural scientist writes up the results of observation and experiment and sends the paper

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to the editor of a professional journal. The editor sends the paper to peer reviewers who appraise the quality of the work. Eventually, if thought to be a contribution to science, the paper will be published. Creationists seem not to do any of these things. They are not usually creatures of laboratory or the field. They do not seek new data from nature to formulate or test their explanatory hypotheses. They do not actively contribute to the literature of the science that appears in the professional journals.

The activities of the creationists are as different from those of natural scientists as one can imagine. They have already accepted what it is that they want to know, and, despite their rigorous protestations, this is nothing more than their interpretation of the first two chapters of Genesis. Specifically, they believe in a creation week of seven days, which occurred as recently as 6,000 to 10,000 years ago and within which all plants and animals were produced essentially in their present form, and in a worldwide flood that drowned all but two of every living creature.

So, after accepting as true what they wish to be true, the activities of the creationists consist of gleaning in the fields of science to see if there are any data that can be used to bolster their beliefs. One simply does not find any data in the sciences that afford proof of a deity creating the world, cosmos, and living creatures in a single week, 6,000 to 10,000 years ago. Finding no proof, the creationists have become rather adept at distorting what scientists find and say.

It is one thing to maintain that the earth and all else originated 6,000 to 10,000 years ago and quite another to ask if the earth had an origin and, if so, when. Therein lies the difference between creationism and science. Genesis deals with supernatural events. That simply cannot be denied. Therefore, the natural sciences have nothing whatsoever to say about it. Genesis gives one account of the origin of the world and its living creatures. The natural sciences have slowly built up a very different explanation. Some will prefer the mystical explanation; others, the scientific. No scientist should be so arrogant as to suggest that one must accept one or the other. It does seem permissible, however, for a scientist to object vigorously to the deviousness of the creationists in distorting the data of science to suggest support for the "creation model."

The second characteristic of the natural sciences is that one starts with a question, a puzzle, about some natural phenomenon. As we have just noted, the creationists do not begin with a question. They begin with the answer and then look for verification. Some have suggested that this way of doing things makes creationism more like the theology of the Middle Ages than the natural sciences.

The third characteristic of the natural sciences had to do with the sources of data—observation and experiment. When a natural scientist asks about the age of rocks in the earth's crust, the data comes from studies of radioactive decay and from the thickness of sedimentary rocks. When a creationist asks about the time of the origin of the earth, he or she frequently relies upon studies of the type undertaken by Bishops Ussher and Lightfoot. The natural scientist seeks answers in natural

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phenomena; the creationist seeks answers in revelation.

The fourth characteristic of the natural sciences had to do with the arrangement of data in conceptual schemes. The creationist rotates this procedure a full 180 degrees: the creationist starts with a particular conceptual scheme and then selects what known data support that scheme.

Our argument becomes considerably more interesting when we consider the fifth characteristic of the natural sciences: how hypotheses are tested by formulating and testing deductions. If we start with a creationist hypothesis—that the world was created in six literal days—one could deduce that all sorts of organisms should occur in all of the geological strata (humans, microbes, and all species would be evident from the earliest to the most recent strata). Careful study of the strata, to test this deduction, reveals that only the smallest and simplest creatures occur in the lower strata, and, as we examine more recent layers, progressively more complex forms appear. One would think that the hypothesis would, thereby, become most improbable. The creationists respond that one merely has to imagine that, when all the drowned creatures settled to the bottom after the flood, the fragile, light ones plummeted to the bottom and the heavy dinosaurs and the like settled slowly. That is not the way bodies settle to the bottom today, but, if the creator wanted it this way, it would occur. In creationism, one can always surmount any puzzle by invoking another miracle. Here, as before, creationism avoids the procedures of science; after all, it most certainly cannot employ them and survive.

Our sixth test of creationism as science is to consider the universality of its statements. Failure again. The major statements of the creationists, derived as they are from the Priestly version in Genesis, are accepted by few outside of the fundamentalist Christian sects. Other Christian denominations, followers of other religious persuasions, and, of course, nonreligious people do not accept the creation myth in Genesis 1. In fact, the creationist position does not even jibe with the Jahwistic story of the creation in Genesis 2.

The seventh test deals with one of the central elements in scientific procedure: verifiability. Merely to mention it in relation to creationism is to realize the hopelessness of the situation. Creationism is something that one accepts for deep religious reasons or because of early indoctrination. There need be no rational reason for such a choice—in fact, there could be none. Faith is not based upon empirical choice, nor do we select our parents. Equally religious people may see the story of creation in Genesis as being "historically and scientifically true," as the creationists insist, or accept it as a metaphorical statement of the relation of a person to his or her god.

There are no intellectual procedures whatsoever that will allow us to establish as "historically and scientifically true" the creation myth of any religion (or support any supernatural statement). The creationist technique pretends that there can be only two hypotheses: the Priestly version of creationism or the scientific theory of evolution. So, if doubt can be thrown on the scientific theory, creationism alone remains. This is equivalent to saying that, if a mammal is not a dog, it must be

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a cat. Pity the poor hippopotamus and the other species of warm-blooded vertebrates covered with hair and which nurse their young.

The last test of science listed was science's ability to progress. Creationism fails this as well. Over the decades, creationism has remained essentially the same in substance and approach. The substance is the fundamentalists' readings of Genesis. Since Genesis changes only as the translator's abilities improve, and these changes will be slight at most, the basic statements of creationism must remain the same for all time. The approach of creationists in their attacks on evolutionary scientists has not been to gather data and refine concepts but, rather, to attempt to discredit the data and explanatory hypotheses of the evolutionary sciences. And to do so they invoke some of the strangest notions that have been advanced since the Middle Ages.

Creationism most surely does not advance. It just seems to go on forever. A scientist can only regard the pretensions of creationists as amusing or fraudulent. Creationists do not, indeed cannot, go about their business using the procedures of the natural sciences. They contribute nothing to our ever-increasing understanding of the natural world. They constitute no more of a challenge to science than do astrologers to astronomy or flat-earthers to geography and navigation.

Religion

It is doubtful that many creationists truly believe that they are scientists. Thus, two important creationist institutions—the Creation-Science Research Center of San Diego and the Moody Institute of Science in Whittier, California—described themselves as "religious" organizations when they each applied for the special postal rates available for nonprofit organizations. They did not describe themselves as educational or scientific—categories that also earn the special rates.

Then why is it that the creationists wish to be considered scientists? Their reasoning was made abundantly clear during the 1981 Arkansas trial:

1. They cannot achieve by legal means their ultimate aim, which is to prevent the teaching of evolution in the public schools.
2. Their alternative therefore becomes to persuade society that their views have scientific support.
3. Thus, they propose that it is only fair to present both the creation and evolution models as equally plausible scientific theories.

Judge Overton's opinion in the Arkansas case finds the creationists' activities to be "a religious crusade, coupled with a desire to conceal this fact."

The creationists give us a fascinating revelation about this in the way they publish two of the basic statements of "creation science": *Evolution? The Fossils*

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Say NO! (Gish 1978) and *Scientific Creationism* (Morris, 1974). Both of these books are available in "general" and "public school" editions. The general editions—especially of the Morris volume—clearly indicate the basis of "creation science" in Genesis and the belief in a creator. In the public school editions, these allusions have been omitted. That does tend to leave the arguments hanging: why would it ever occur to anyone that the earth was only a few thousand years old? The geologists never devised that one on their own, so the public school student is left to wonder. (No problem for the private school students; they could use the general editions in which the creationist answers are clear.)

But this is far from saying that the creationists are harmless. They can—and are—doing great mischief in the public schools of this nation and in the editorial rooms of the textbook publishing houses. They are a threat to our dealing with the problems of this world in a rational manner—not because of their creationist views alone but because the creationist mind is frequently associated with other positions that seem socially and philosophically damaging. I believe that the major threat of creationism is that, in the long run, it is far more likely to damage religion than science.

Note

This article is a slighted revised version of a paper presented at the symposium, "A Scholarly Examination of Genesis and Creation Science," held at the University of California at Riverside on May 8, 1982.

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Bobbing for Dinosaurs: A Forensic Scientist Looks at the Genesis Flood

Walter F. Rowe

Modern forensic science and taphonomy (that branch of paleontology concerned with how plant and animal remains become fossils; *see* Fenton and Fenton, 1989; Shipman, 1981) demonstrate that the bodies of dead animals do not behave as most creationists claim in their accounts of Noah's flood (Genesis 6:5–8:19). Dead bodies float or sink depending upon the quantities of fatty tissue they contain and the extent of decay they have experienced. Depending upon the climate and the season of the year, predators may immediately destroy floating bodies or leave them to float indefinitely.

Creationists have long used the Noachian (or Genesis) flood to explain the geologic column—the distribution of plant and animal fossils in the rock strata of the earth. The classical modern statement of creationist flood geology is John C. Whitcomb and Henry Morris's *The Genesis Flood*, first published in 1961. According to these authors, fish and other marine creatures were trapped by sediment washed down from the land or by bottom sediments stirred up by the violence of this catastrophe. Rivers swept masses of vegetation and other debris into the sea, along with the occasional animal. Land animals would be buried in order of their elevation above sea level and their mobility. As Whitcomb and Morris said:

> As far as land animals and man were concerned, their greater mobility would have enabled most of them to escape temporarily to higher ground as the waters rose, only occasional individuals being swept away and entombed in the sediments. Eventually, of course, the floodwaters overtook even those who had fled to the highest elevations, but in most cases these men and animals would not be buried but simply drowned and then carried about by the waters until finally decomposed by the elements. (1968:266]

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The rising flood waters also account for Cope's law—the phenomenon of evolutionary increase in size. Concerning the fossil evidence supporting Cope's law, Whitcomb and Morris write:

> [T]hey can once again be most easily explained in terms of the greater mobility of the larger, stronger animals, and therefore their generally greater ability to retreat from the rising flood waters and to escape being caught in the swollen streams rushing downward from the hills. [1968:285]

It is at least superficially plausible that a worldwide flood such as that envisioned by some creationists would result in a distribution of animal fossils like that found in the geologic column. Critics of this theory, however, have expressed doubts about the precise ordering of animals by elevation prior to death that this theory requires. Michael Ruse somewhat sarcastically observes:

> The detailed record, from simple to more complex, from general to special, from fish to man, is entirely an artifact of the flood. There was *not one* human being, or horse, or cow, or fox, or deer, or hippopotamus, or tortoise, or monkey, who was so slow, or so stupid, or so crippled, that he/she/it lagged behind his/her/its fellows, and thus got caught down at the bottom of the hill. *Not one!* Conversely, there was not one dinosaur, or trilobite, or mammoth, that was lucky enough, or clever enough, or fast enough, to climb up to the top of the hill, and thus escape the fate of its fellows. *Not one!* And this we are asked to believe as sound science? [1982:315]

Even granting that every animal somehow reached its "proper" elevation prior to being drowned and washed away in the flood waters, the subsequent segregation of animal fossils in the geologic column contradicts what is known about the buoyancy of dead bodies. Nature has conducted numerous experiments on the effects of mass drownings, the results of which flatly contradict the predictions of the creationist Genesis flood model. Modern wars, mass disasters, and murders provide similar evidence.

Those readers with a curiosity about drowning, the floating of dead bodies, and postmortem putrefactive changes may consult any number of standard references, such as *Gradwohl's Legal Medicine* (Camps, 1976:78-100, 349-355) or *Medicolegal Investigation of Death* (Spitz and Fisher, 1980:12-32, 351-366). Although these works limit their discussions to human remains, the same principles apply to all vertebrates. Those principles pertinent to the present discussion may be briefly summarized:

1. The densities of the bodies of humans and other vertebrates are very close to that of pure water (1000 kg/m^3). Actually, the densities of the bodies of many

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invertebrates are also close to that of pure water. Given the variation of densities observed in a typical animal population, the bodies of some of the animals will float while those of others will sink. Lean animals with little adipose tissue will sink; obese animals, on the other hand, will float. If an animal drowns, the small amount of inhaled water will usually add just enough weight to the body to cause it to sink. If the animal dies of some other cause, its body will tend to float. Sea water has a density of 1,026 kg/m^3; consequently, some animals whose bodies would sink in fresh water will float in sea water. In the case of human bodies, clothing may keep the body initially afloat until it becomes sodden and weighs the body down.

2. Even if a dead body initially sinks, putrefactive changes will generally cause it to rise to the surface. Animal remains decay through two processes: *autolysis* (decay brought about by the body's own enzymes) and *putrefaction* (decay produced by microorganisms). Putrefaction occurs when microorganisms invade the body's tissues from the gastrointestinal tract (and to a lesser extent from the lungs). These microorganisms generate large quantities of putrefactive gases which fill both tissues and body cavities. The putrefactive gases decrease the body's density and increase its buoyancy. Putrefactive gases are able to impart sufficient buoyancy to a dead body to overcome the weight of clothing and inhaled water. If a body sinks initially, the air in its lungs is forced into the watery tissues of the body by the pressure of the water. Once the body begins to rise only slightly, the atmospheric gases escape into the lungs and other body cavities, further enhancing the body's buoyancy. Not all bodies return to the surface. If the water is cold, putrefaction may be indefinitely arrested.

Although direct evidence for the existence of putrefactive microorganisms in past geologic epochs is lacking, fossil microorganisms have been found in strata believed to be 3.5 billion years old—strata near the bottom of the geologic column (Brock et al., 1984:758-766). There is *indirect* evidence for putrefactive microorganisms in past geologic epochs: the impression left by the bloated body of a late Oligocene or early Miocene rhinoceros in a basalt flow in the Columbia River basalts. The rhinoceros's body was evidently floating in a shallow lake into which lava flowed, eventually encasing the cadaver and preserving its form as an external mold (Fenton and Fenton: 1989:6-7).

3. The eventual sinking of floating animal remains in an ocean environment depends upon the activities of predators. In cold waters, remains may float for weeks or months because of the relative inactivity of marine organisms. In warm waters, remains may be attacked and destroyed within hours. For example, survivors of the U.S. Navy destroyers and aircraft carriers sunk in the surface engagement off Samar during the battle of Leyte Gulf in October 1944 were attacked and dismembered by sharks within hours of their ships' sinking (Y'Blood, 1987:235-241).

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On the other hand, the body of a man drowned in the Chesapeake Bay in December was found floating substantially intact eight months later (Spitz and Fisher, 1980:363). Intact bodies of victims of the *Titanic* disaster (some in life jackets and others apparently not) were encountered by ships in the North Atlantic sea lanes for many weeks after the *Titanic* sank on April 15, 1912 (Wade, 1980:378). The size of the dead body will also play a role: large animals are more difficult to dispose of than small ones. Fresh water lakes and rivers usually lack significant predatory species; however, fish and crustacea will feed upon the soft tissues of the dead body.

The floating or sinking of animal carcasses is, therefore, very much a matter of environment and individual circumstance. Within any group of animals, which ones would sink and be deposited first in the flood sediments and which would continue to float until the flood waters receded would be more or less a matter of chance.

Nature has conducted numerous experiments in mass drownings that provide direct tests of the Genesis flood model. Charles Darwin described one mass drowning in South America:

> I was informed by an eye-witness that the cattle in herds of thousands rushed into the Parana, and being exhausted by hunger they were unable to crawl up the muddy banks, and thus were drowned. The arm of the river which runs by San Pedro was so full of putrid carcasses that the master of a vessel told me that the smell rendered it quite impassible. Without doubt several hundred thousand animals thus perished in the river: their bodies when putrid were seen floating down the stream; and many in all probability were deposited in the estuary of the Plata. [1839:133-134]

The eruption of Krakatau was an "experiment" on an altogether larger scale. After a series of smaller eruptions extending over a number of months, this volcano experienced its paroxysmal eruption on August 26, 1883. The collapse of the volcano's caldera generated enormous tsunamis (tidal waves) that inundated the coasts of Java and Sumatra. The *London Times* published a description of the aftermath of this deluge:

> The British ship *Bay of Naples* had called at these islands and reported on the same day, when 120 miles from Java's First Point [a point of land near the southern end of the Sunda Strait], during the volcanic disturbances, she encountered carcasses of animals, including even those of tigers, and about 150 human corpses, of which 40 were those of Europeans, besides enormous trunks of trees borne along by the current. [Simkin and Fiske: 1983:133]

A similar news report of the aftermath of the Genesis flood might have read:

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> Noah's ship *Ark* (of Babylonian or Sumerian registry) reported encountering carcasses of animals, including ichthyostega, seymouria, dimetrodons, apatosauruses, triceratops, brontotheria, smiledons, and numerous human corpses, of which some were *Homo sapiens* and others were *Homo erectus* and *Homo habilis*.

This unholy stew of carcasses would have been deposited promiscuously (and unsegregated) as marine predators devoured them (or left them alone) and the flood waters receded.

A common creationist charge is that both modern cosmogony and evolution violate the second law of thermodynamics, because both supposedly require order to arise from disorder. There are flaws in this argument, but, on the creationists' own terms, flood geology likewise requires that the ordering of fossils in the earth's geologic strata arise from a chaotic event: a worldwide flood. Creationists like to dismiss evolution as "only a theory." My favorite rejoinder is that creationism isn't *even* a theory. When examined in the light of well-known and thoroughly researched scientific phenomena, creationist flood geology fails the most basic and simple test known to forensic science: bodies don't pile up the way creationists insist they must.

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The Evolution of Improved Fitness by Random Mutation Plus Selection

Edward E. Max

A Difficult Concept

The theory of evolution includes a number of ideas that many people find difficult to grasp intuitively. One of the most difficult seems to be the notion that life—in all its complexity—derives from *random genetic mutations* selected over time. It is much easier to imagine that a structure so beautifully constructed as the human eye was designed by an intelligent creator than to believe that chance events could have had a major role in its genesis. Creationists capitalize on this conceptual difficulty, presenting several arguments that appear to demonstrate that random mechanisms could never lead to even a single functioning protein, let alone an eye. These arguments can be refuted by theoretical counterarguments; yet many people have difficulty accepting these counterarguments at an intuitive level without a clear biological example of the creative power of random mutation plus selection. Some time ago, I realized that such an example was provided by experiments related to my own laboratory research, which concerns the genes encoding the immune system proteins known as antibodies. Because antibody genes are not well known to the general public, I decided to write this article in the hope that it might be useful for readers impressed with creationist arguments.

The Creationist View of Random Mutation and Selection

Before discussing antibody genes, it is worthwhile to consider what the creationists

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have to say about randomness versus design. Let's focus on two arguments that are well beloved by the creationists because they contain some undeniably true elements and some logic. First, the statistical argument against the evolutionary origin of proteins. Proteins are large biological molecules constructed of chains of smaller subunits, known as amino acids, linked together like the cars of a train. There are twenty different amino acids, and the specific sequence of these amino acids determines the shape and properties of the protein. A typical protein is composed of several hundred amino acids in a strictly defined order. The creationists ask: what is the probability that the correct sequence of amino acids of a specific protein—for example, the 141 amino acids which comprise the human oxygen-carrying protein globin—could have been selected by chance? The total number of possible 141-long amino acid sequences is 20^{141}—an *extremely,* incomprehensibly large number. So, the statistical probability of the proper sequence ever appearing from a random assortment of amino acids is so small as to render this mechanism of random selection impossible as an explanation for the origin of a protein sequence. In a picturesque simile, the creationists liken the probability of correctly assembling a protein by this mechanism to the likelihood that a tornado blowing through a junkyard could assemble a 747 airliner.

The second argument that the creationists put forward against the notion of random mutation as the source of evolutionary change is the idea that mutations are harmful. According to the creationists, if you take a well-running complex biological machine and subject it to random alterations, you could scarcely expect to have made any improvements and almost certainly will have harmed the organism. Consistent with this idea, the mutations that we see in humans are essentially all detrimental, causing such genetic diseases as sickle cell anemia, muscular dystrophy, cystic fibrosis, and the like. To explain adaptive changes in populations—such as the famous darkening of the peppered moth population (which occurred when the soot-darkened trees resulting from heavy industry made light-colored moths resting on a tree easier targets for hungry birds)—the creationist argue that the genes for dark color were present in the original population from the time of creation; given this assumption, the shift in the predominant coloring of the population could simply reflect selection operating on existing genes without requiring new mutations. Creationists argue that the essential relationship between natural selection and mutations is that selection acts conservatively to weed out mutations and to prevent their spread into a population.

Logical Refutation of the Creationists' Arguments

Although these creationist points contain some element of truth, they are certainly not valid as proofs of the impossibility of evolution by selection of random mutations. Although most mutations *are* indeed deleterious, there are very rare ones

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that are beneficial; and it is these rare beneficial mutations that provide the basis for evolutionary progress. Naturally the human mutations we know most about are the detrimental ones, because genetic diseases are intensely investigated by medical scientists and because detrimental mutations are more common than beneficial ones. In organisms as well adapted to the environment as humans are and as varied in genetic makeup from individual to individual, it is difficult to imagine how a beneficial mutation would ever be recognized. In populations undergoing environmental stress (for example, insects subjected to pesticides), beneficial mutations are more easily recognized, although examples in which we can rule out selection of preexisting genes are hard to come by. One reason for this is that the genetic makeup of an entire population in the prestressed state is difficult to assess.

As for the argument concerning the statistical improbability of obtaining a specific 141 amino acid sequence by looking for the correct sequence among randomly generated sequences, scientists would agree that this mechanism could not explain the generation of protein sequences. However, this mechanism is not the evolutionary explanation for the origin of protein sequences; it is simply a straw man—the creationist version of evolution—used repeatedly by the creationists to lead audiences into thinking that evolution is illogical. One reason why the creationist version is invalid as an evolutionary model involves the "hindsight fallacy." You might be impressed if I told you that I had sealed in an envelope a list of playing cards that exactly match a bridge hand dealt from a randomized deck of cards; the odds of such a match occurring by chance are less than $1/10^{21}$. But you would be less impressed if I told you that I had written the list and sealed it *after* I had dealt the cards and looked at them. Similarly, the creationists' argument about the improbability of a random amino acid sequence matching that of a specific protein ignores the possibility that existing protein sequences may represent only a small subset of the sequences that could potentially serve to support life. For the globin example, many mammalian globins function similarly to the human globin even though they differ from that sequence at 5 to 30 percent of their amino acid positions; many other variations on the globin sequence would undoubtedly serve as well. The creationists' model, by requiring that a *specific* known sequence be achieved, exaggerates the difficulty of finding a biologically workable sequence.

Lessons from Computer Simulations

A more significant problem with the creationist model for the role of randomness in evolution concerns the nature of the selection step. In a beautiful analysis of this argument, British biologist Richard Dawkins (1986) simulated the creationists' selection model on a computer. He programmed the computer to generate random sequences to see if it would ever generate a line from Hamlet: "Methinks it is like a weasel." This line has twenty-eight characters (including the spaces), so the com-

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puter was programmed to make twenty-eight selections from the twenty-seven possible characters (twenty-six letters plus space). A typical output was "MWR SWTNUXMLCDLEUBXTQHNZVJQF." Since there are 27^{28} different possible ways of choosing twenty-eight times from twenty-seven alternatives, one can calculate the probability of picking the correct sequence and, based upon the speed of the computer, estimate how long on average one would have to wait for the correct sequence to appear. Dawkins figured about a million million million million million years. If this were the best way protein evolution could be conceptualized—by selection in a *single step* from random sequences—one might conclude that the protein could not have evolved. However, as a model for evolution, this computer model is subject to the computer mavens' dictum: "Garbage in, garbage out"—meaning that, if your computer is programmed with an incorrect model, it can generate only meaningless results.

As I pointed out already, the creationists' single-step selection model is a straw man designed to ridicule the concept of randomness as a component of evolution. This fake model is effective with audiences which do not realize that evolution posits an entirely different role for randomness. The evolution model is that amino acid sequences evolve by *successive steps* in which random mutations of preexisting sequences are subjected to selection; any rare mutant that provides more efficient function is propagated to future generations, in which the process of mutation and selection is repeated over and over. When Dawkins terminated his computer program simulating the straw man "creationist version" of evolution through single-step selection, and rewrote a program that more closely approximates the "evolutionist version" of evolution, the results of the simulation were quite compatible with evolution occurring through random mutation and selection. Dawkins programmed the computer to generate an initial sequence randomly, as in the first model, and the computer produced: WDLMNLT DTJBKWIRZRESLMQCO P. Then, following Dawkins's revised program, the computer made multiple copies (progeny) of this sequence while introducing random "errors" (mutations) into the copies. The computer examined all the mutated progeny and selected the one that had most similarity (however slight) to the line from Hamlet. This selected sequence was used as the basis for another generation of progeny with further mutations, from which a selection was made—and so on. By ten generations, the sequence had "evolved" to: MDLDMNLS ITJISWHRQREZ MECS P. By thirty generations, it was: METHINGS IT ISWLIKE B WECSEL. Instead of taking millions of years, the computer generated METHINKS IT IS LIKE A WEASEL in about half an hour—at the forty-third generation. Thus, a cumulative multistep model for evolutionary selection of random mutations is not at all implausible, given a mechanism for replicating imperfect copies and strong selective pressure. (The replication mechanism is, of course, a big "given"; how such a mechanism might have developed is a separate question concerning the *origin* of life rather than its *evolution* and is not the subject of this article.)

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A Biological Model

This computer simulation exercise is convincing as a theoretical model of evolution by random mutation, but can we find a model even closer to the real world of evolution—that is, the world of biology? The model that I will discuss—mutations in antibody genes—should make it very difficult for the creationists to continue to insist that random genetic mutations are always harmful and cannot lead to improved function in a real biological system.

To appreciate the beauty of the mutational evolution of antibody genes, it is necessary to understand as background the deep mystery that this system posed before recombinant DNA technology made it possible to probe antibody genes directly, beginning about ten years ago.

It is common knowledge that a child who comes down with the measles and then recovers is immune to further attacks by this virus. In fact, even when no diesease results, immunity can be generated by inoculation with various weakened forms of viruses, bacteria, and bacterial toxins. The protection that results from such vaccines is not due to a general strengthening of the body, since one feature of such immunity is that it is highly specific; inoculation with a vaccine based upon a particular strain of bacterium or virus often does not protect against infection by even closely related strains. Furthermore, experiments of the last century have demonstrated that in many cases the immunity depended upon specific proteins that were present in blood after vaccination. These proteins, called *antibodies* (or immunoglobulins), were found to be able to bind specifically to the foreign agent in the vaccine, known as the *antigen;* the combination of antibody with antigen can kill invading bacteria, neutralize invading viruses, and target these invaders for destruction by the wandering "cell eaters," or *phagocytes*, of the body. Antibodies are secreted into the bloodstream by a specific kind of white blood cell called the *B lymphocytes*.

If one takes blood samples from an animal at different times before and after immunization, one generally finds that the "preimmune" sample does not contain significant amounts of antibody specific for the immunizing agent. Beginning several days after immunization, specific antibody begins to increase in the blood, often peaking at one to two weeks (the time course is somewhat variable depending upon the nature of the antibody, the dose, the recipient, and so forth). This is the *primary response*. A subsequent administration of antigen (a "booster") produces a much faster response, with higher amounts of specific antibody—*secondary response.*

An important feature of the antigen-antibody reaction is the *tightness* of the binding between these two molecules. If pure antibody and antigen are mixed together in a test tube as very dilute solutions, one can determine how many of these molecules remain free and how many join together as an antigen-antibody complex. (In reality, such complexes are constantly being formed, breaking down, and reforming; however, averaged over the millions of molecules in solution, it

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is possible to measure a stable average of the numbers of free and complexed molecules.) The "tighter" an antigen-antibody complex, the higher the ratio of antibody that is complexed versus that free in solution. In general, during the course of an immune response, the antibodies grow not only in numbers but also in the "tightness" with which they bind antigen—their *affinity*. The secondary response generates high-affinity antibodies, and the affinity often rises still further on subsequent booster shots of antigen. By binding more tightly to antigen, high-affinity antibodies are more efficient in carrying out their protective tasks.

Antibodies were found early on to be proteins—that is, they are made of amino acids whose sequence determines their properties, including their antigen-binding specificity. The information governing exactly which amino acids are used for each position in any protein is stored in the *gene* for that protein. For each gene, the sequence information is encoded chemically in the sequence of subunits (*nucleotides*) in the long linear molecule of deoxyribonucleic acid (DNA).

The recognition that our immune systems are capable of producing highly specific antibodies against an immense number of bacterial and viral products led to three profound mysteries: (1) how does the body realize exactly which antibody genes need to be activated to fight a specific infection; (2) how does our DNA store the immense amount of information necessary to encode specific antibodies against all the foreign invaders that we may encounter; and (3) how can the progressive increase in antibody affinity during an immune response be explained?

At this point, I recommend that you stop reading for a moment and consider how *you* might design a system to have these immensely beneficial properties I have described. You may then appreciate the difficulty of the problem and the excitement of scientists as they learned the answers to these questions.

Answer #1: Clonal Selection. An answer to the first question was suggested by MacFarlane Burnet in a hypothesis known as the *clonal selection theory*. According to this model, each of the millions of B lymphocytes in an animal has the potential to become a mature antibody-secreting cell; but each mature cell can make only one species of antibody, with a particular amino acid sequence and thus a particular antigen specificity. Before immunization, each B lymphocyte displays on its surface a membrane-bound form of the antibody that it will be able to secrete. When an antigen—for example, polio virus—is injected into an animal, it circulates among the lymphocytes in the blood and binds to the cells displaying anti-polio antibodies on their surface. Binding of the virus to these cells triggers them into action: they proliferate, producing many daughter cells—clones—all specific for polio; and these progeny cells turn into miniature factories pouring out large quantities of anti-polio antibody into the bloodstream. B lymphocytes that cannot bind polio remain in the resting state. This mechanism explains how each antigen can trigger the production of those specific antibodies that are capable of binding to it. The clonal selection theory was verified through a series of elegant experiments

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in the 1960s (Ada and Nossal, 1987).

Answer #2: Diversity Through Combinatorial Assembly. The second question—how the myriad antigen specificities are encoded in the DNA—proved to be much more difficult. Even the initial step in answering this question—that of determining the amino acid sequence of antibody proteins—presented a problem: when scientists immunized animals and then attempted to purify the antigen-specific antibodies in order to determine their structure, mixtures of different antibodies with different amino acid sequences were obtained, making it impossible to determine a clear sequence. The mixtures resulted from the fact that, in a single animal, a particular antigen may be able to bind with a number of different antibodies, all with different sequences and made by different B lymphocytes. However, a solution to the problem of antibody mixture was found when it was realized that, in patients (or experimental animals) with cancers of B lymphocytes, each malignancy derives from a single cell that turned cancerous; that is, all the cancer cells are a clonal line from an original progenitor B lymphocyte, which, according to the clonal selection theory, could produce only one particular antibody sequence. By growing such cancer cells in the laboratory, it was possible to harvest large amounts of homogeneous monoclonal antibodies that could be used for amino acid sequence analysis. A more modern technique for obtaining monoclonal antibodies is to construct a *hybridoma*, a cell fusion between a normal B lymphocyte and a cancer cell; such hybrid cells continue to make the antibody characteristic of the normal B cell and can be grown indefinitely in the laboratory.

Structural studies of homogeneous antibodies revealed that each antibody molecule is composed of four protein chains: two identical larger units ("heavy" chains) and two identical "light" chains. The amino acid sequences of these chains were found to have a remarkable property. The first hundred or so amino acids form a domain that is different for virtually every antibody that is sequenced, while the rest of the sequence is identical for every antibody chain of a particular class. (Among light and heavy chains, there are about ten different classes of antibody chains, but these need not concern us.) Not surprisingly, the variable domain is the one that determines the antigen specificity of the antibody. The second question we considered above can then be reformulated: how can the diversity of amino acid sequences of the variable domains of antibodies be encoded in the DNA, and how do the constant domains manage to remain constant in the face of such diversity of variable regions?

These questions produce a truly amazing answer. In simplified form, it turns out that the gene that encodes each antibody variable domain is created within each lymphocyte out of DNA elements that are separated in all the nonlymphoid cells of the body (Tonegawa, 1983). A heavy chain variable domain gene is made up of three elements, known as V_H, D_H, and J_H, and the comparable light chain gene is made of two, V_L and J_L. These five elements are often referred to as germline

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elements, since they are separated in the DNA of germ cells (egg and sperm) which do not rearrange these elements as B lymphocytes do. Each lymphocyte can "choose," Chinese menu style, one V_H (out of about 500), one D_H (out of about twenty), one J_H (out of four), one V_L (out of about 100), and one J_L (out of four); but there is only one gene for each class of the nonvariable domain of antibodies, so these domains remain constant in all antibodies of a given class. Thus, through this Chinese menu approach, there are at least $500 \times 20 \times 4 \times 100 \times 4$—or about sixteen million—possible combinations of antibody gene elements that can be assembled by lymphocytes. Actually, the number of different *antibodies* that can be generated this way is even larger because there is some "flexibility" at the borders where the elements are joined together; this flexibility further increases the potential diversity, although at the cost that many attempts to join the gene elements yield nonfunctional genes. Sometimes a cell has to make several attempts to assemble the germline elements before a functional antibody can be produced; the nonfunctional assemblages remain as relics in the cell and its progeny. The impressive diversity of antibodies produced with combinations of these germline elements makes it likely that, for most foreign antigens, there will be antibody on the surface of some B lymphocytes that can bind the antigen—with low affinity, perhaps, but enough to initiate an immune reaction. This provides the answer for the second of the three mysteries of antibody formation.

Answer #3: Evolution of Affinity. It is in considering the third and last question—how antibody affinity increases during an immune response—that we come to the *raison d'etre* of this article. For investigations have clearly demonstrated that the mechanism of the affinity rise that progressively improves the efficiency of antibody function is random mutation and selection. The evidence comes from analysis of several immune reponses in inbred strains of mice, which all paint the same general picture (Wysocki et al., 1986; Griffiths et al., 1984). The responses are analyzed by constructing hybridomas from B lymphocytes taken at different times before and during an immune response and then determining the structure of the antibody genes in these cells. Before immunization and during the early phases of a primary response, the antibody gene sequences are all found to be constructed from unaltered combinations of the five germline elements described above. But later, and in the secondary response, the sequences clearly show evidence of mutation: many are different from the sequences of the germline elements from which they were constructed. Because the animals in these experiments are inbred, all the individuals are like identical twins. They all start with the same germline gene elements, and, for particular cases of specific immune responses, these germline gene elements are completely known. Therefore, one can be certain that the apparently new sequences that regularly appear in antibodies of the secondary response were not present in the germline DNA with which the animal was born and could only have been derived by a mutational process.

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This process has several interesting properties: it is unique to antibody genes; it occurs only in B lymphocytes; it increases the low level of normal mutation (due to errors in the copying of DNA) by more than one-thousandfold, and therefore is referred to as *hypermutation;* and, finally, the distribution of the mutations along the DNA molecule is striking. The mutations are found only in the region of an assembled variable domain gene and do not occur in the unassembled antibody gene elements which have not been chosen for expression in a given lymphocyte. Yet, aside from their clustering near the assembled variable domain gene, they appear to be random: different mutations occur in different animals, without any clear pattern in the nucleotide changes. Some mutations do not alter the amino acid encoded in the DNA; indeed, some fall completely outside the gene, in nearby "spacer" DNA where they can have no effect on antibody production. In several cases it has been possible to isolate mutated antibody genes from the B lymphocytes of a *single animal* and to trace the sequences through several stages of mutation (Clarke et al, 1985). With this information, one can construct a genealogical tree of antibody sequences much like the diagrams of species divergence which illustrate evolutionary "genealogies." In constructing such an antibody sequence tree, it is important to demonstrate that the B cell hybridomas under study derived from a common clonal ancestor and do not represent cells with similar but independently derived mutations. Derivation from a common clonal ancestor can be established by logic very similar to that discussed in an earlier article of mine arguing that shared errors provide evidence of common ancestry (Max, 1986). In the present case, this principle has been applied by demonstrating that the B cells that appeared to be related according to the sequences of their functional antibody variable domain genes also shared identical relics of nonfunctional assemblages ("errors") of their antibody gene elements and, thus, had to have come from a common ancestral B lymphocyte.

The model suggested by these findings provides an unambiguous biological example of the power of random mutations and selection. When antigen enters the body, it triggers a small number of B lymphocytes—those whose surface antibody can bind it—to multiply and secrete antibody. These early responding antibody sequences are made of assembled germline gene elements in unaltered form and frequently have relatively low affinity. As the immune response continues, hypermutation is initiated and begins to generate antibodies with altered structure. The hypermutation mechanism acts randomly and independently in the different clonal progeny cells, introducing random alterations in the antibody sequence in each cell. Most of these alterations probably lead to unaltered or reduced affinity for antigen or destroy the antigen binding completely. However, rare mutations lead to antibodies of higher affinity. As the existing antibodies help to remove progressively more antigen from the circulation and antigen concentration falls, selection for high affinity becomes the crucial factor in determining which cells will be stimulated to secrete their mutated antibodies. With lower amounts of antigen present, the cells

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expressing low-affinity antibody on their surface become progressively less able to bind and to be stimulated by antigen; thus, they stop proliferating and reduce their secretion of antibody. In contrast, the cells with high-affinity antibody continue to bind antigen and thus continue to be stimulated to proliferate and secrete antibody. As the antigen concentration continues to fall and mutation continues, the intensity of the selective pressure for high affinity increases, sometimes leading to affinity levels one hundredfold higher than that of the original unmutated antibody. The "competition" for efficient antigen binding has been shown to be the selective force driving the rise in antibody affinity, since, if antigen is repeatedly administered to prevent the drop in antigen level and thereby eliminates the selective pressure for efficient antigen binding, antibody affinity does not rise (Eisen and Siskind, 1964). As antigen becomes completely cleared from the bloodstream, the amount of antibody secreted gradually falls, but a subset of the last group of highly efficient cells persists as a quiescent population, ready to respond with rapid secretion of high-affinity antibody should they ever be triggered by another encounter with the same antigen.

Conclusion

Clearly, what we observe in the immune response is evolution in miniature. In this model, we know the structure of a gene at the beginning of the experiment and then observe the accumulation of randomly induced mutations under natural selection for progressively improved function. This model of evolution is reminiscent of the computer simulation discussed earlier, but it has advantages as a conceptual model. First, it is a real biological phenomenon rather than a theoretical simulation. And second, as in real phylogenetic evolution, the selection pressure is for biological function rather than for a specific target sequence chosen by an intelligent "creator" of the computer program. Thus, the different sets of mutations observed in the high-affinity antibodies represent different solutions to a particular selective challenge—just as alternative globin sequences in different species represent alternative solutions to the need for an oxygen-carrying protein.

Obviously, there are differences between this kind of antibody evolution and the phylogenetic evolution that produced the diversity of plants and animals that we find on our planet. But none of these differences critically weaken the logic of the analogy between these two kinds of evolution as examples of random mutation and selection. Both involve sequences altered by random mutations, including rare beneficial alterations that "take over" the population because of their increased efficiency in proliferating under selection pressure; then these mutants are themselves "taken over" by later mutations, leading to progressively more efficient structures.

Thus, the molecular immunogenetics evidence of antibody evolution that I have

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described makes it clear that, contrary to the creationists' claims, the combination of random mutation and selection can be a potent creative biological engine for the generation of progressive functional improvements. This evidence alone does not prove that life evolved as Darwin suggested, but it highlights the emptiness of another invalid, though superficially appealing, creationist objection to evolution. And to people who can appreciate the amazing complexity of life as a thing of wonder, it reveals in the immune system another example of an undesigned but beautifully functioning system.

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Creationist Evidence Destroys the Geologic Time Scale—Fact or Fiction?

James S. Monroe

Many creationists claim that the geologic time scale is a fallacy perpetuated by advocates of the false doctrine of evolution. The evidence for this claim, so they say, is clear and irrefutable: numerous fossils and human artifacts are in the wrong place for evolution. Therefore, if one examines this "out-of-place fossil evidence" with an open mind, the conclusions are inescapable: the time scale is a myth, stratified rocks contain no evidence for evolution, and the earth is probably young. Much of their "out-of-place fossil evidence," especially human footprints in ancient strata, has been considered elsewhere (Conrad, 1981; Weber, 1981; Milne and Schafersman, 1983; Cole and Godfrey, 1985; Kuban, 1986a, 1986b; Monroe, 1987).

Some additional creationist so-called evidence is examined in the following pages—evidence that they claim demolishes the geologic time scale. This examination is in response to comments made by David Johannsen in an *Origins Research* debate between the two of us in 1984. I had argued that, if flood geology has any validity, we should find numerous human remains and artifacts in the geological deposits. Johannsen's response was that such remains and artifacts have indeed been documented, and he referred to J. R. Jochmans (1979) and E. A. von Fange (1981), among others.

As further research reveals, however, this "evidence" is based mostly upon distortions, out-of-context quotes, faulty reasoning, and a willingness to accept almost anything, no matter how unsupported, that is deemed inimical to evolution. So, let us take a close look at it.

Miocene Human Jawbone

The Miocene human jawbone must surely be a delight to anti-evolutionists. Not only was a "modern-looking human jaw" found in ancient strata but evolutionary scientists apparently tried to keep this fact from the public. An examination of the

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facts, however, shows that Jochmans has misrepresented legitimate fossils and has made several unsupported claims:

> In 1958, Dr. Johannes Huerzeler [*sic*], of the Museum of Natural History in Basel, Switzerland unearthed a human jawbone at a depth of 600 feet, in a coal mine in Tuscany, Italy. The bone had belonged to a child, between the ages of five and seven. Though flattened like a sheet of iron, the jaw was declared by several experts to be not only human, but modern-looking at that. [1979:3]

Jochmans further claims that the fossil came from Miocene strata twenty million years old and that "Dr. Huerzeler [*sic*] declared it to be the 'world's oldest man. . . .'" Apparently, Walter T. Brown also believes this is a modern-looking, out-of-place fossil and claims that it, among others, is "ignored by evolutionists" (1983:211).

Dr. Hurzeler did in 1958 recover remains at 600 feet in a coal mine at Tuscany, Italy, but the remains were of a nearly complete skeleton of *Oreopithecus*, a primitive primate. He also collected other *Oreopithecus* remains, including teeth and jaws of "at least fifty individuals" (Straus, 1963:146).

Jochmans's claim that the jawbone, presumably one of Dr. Hurzeler's fossils, was "modern-looking" and from a child five to seven years old is unsupported. He mentions several experts but does not specify who they are. It is certain that Dr. Hurzeler was not among them even though Jochmans said he "declared it to be the 'world's oldest man.'" Dr. Hurzeler stated in correspondence that he knew nothing of the report claiming any of his fossils were human. In fact, he said in effect that the report appeared to be the fanciful elaboration of a journalist with little technical knowledge.

Dr. Hurzeler's discoveries, especially the nearly complete skeleton, did create a good deal of interest in anthropological circles, and several articles appeared in the popular press (*New York Times*, 1958a, 1958b, 1958c, 1958d, 1958e; *Science News Letter*, 1958; *Time*, 1958; *Life*, 1958). These articles did carry such statements as: "It is believed to be the earliest progenitor of man yet discovered" and "Oreopithecus appears to have been clearly manlike," but none state that it was a modern-looking human.

In short, Jochmans's claim is not only refuted by his own source, Dr. Hurzeler, but no support can be found in scientific articles (Simons, 1960; Strauss, 1963), textbooks (Buettner-Janush, 1966; Poirier, 1981), or in the popular press. Perhaps Jochmans has some other unspecified source, but one thing is clear: he did not check the published accounts nor did he contact the museum in Basel, Switzerland.

Jochmans even has the age of the fossil wrong. He claims that the jawbone was "geologically dated at *20 million years*." All of the sources I can find say ten to twelve million years.

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The preceding has dealt with only nine lines of Jochmans's fifteen-line statement. The remaining six lines are also error-riddled:

> Here were human remains *more modern* in appearance than all the "apemen" forms ever found—yet they were *five times* as old as any of them. The bone raised more problems than answers—so the find was quickly "shelved," and no further work was ever done to give it due recognition.

Briefly, I cannot find any source that substantiates Jochmans's first claim. In fact, *Oreopithecus* is figured as a possible progenitor of *Australopithecus* in *Life* (1958). And finally, in his last sentence, Jochmans implies a coverup. Creationists commonly charge that scientists ignore or explain away evidence that does not "readily fit into an evolutionary framework" (Johannsen, 1984:13). But this is patently false. All of Dr. Hurzeler's fossils are available for study and have been studied by, among others, William L. Strauss, Jr. (1963). As a matter of fact, it is not altogether clear that Jochmans is referring to Dr. Hurzeler's 1958 fossil finds. Jaws were found in 1958 but are rarely mentioned in any of the sources. The very first discovery of *Oreopithecus* was a small jaw found in Italy in 1872, which "was classified as *Oreopithecus*, an extinct mountain ape, and was promptly forgotten" (*Newsweek*, 1956:65). Perhaps this is where Jochmans got the idea of a coverup.

The 1958 fossil discoveries reinforced a concept already held by Dr. Hurzeler: *Oreopithecus* was an early hominoid (*Scientific American*, 1956; de Terra, 1956), possibly on the line leading to modern humans. Others, however, thought that "*Oreopithecus* was a primitive, aberrant member of the Hominidae" (Strauss, 1963:174) or preferred to place it in a separate hominoid family, the Oreopithecidae (Buettner-Janusch, 1966:127). Since its earliest discovery in 1872, "*Oreopithecus* has always been a taxonomic problem because it exhibits a number of characteristics intermediate between monkeys, apes, and hominids" (Poirier, 1981:153).

There was some controversy about *Oreopithecus*, but the controversy was about its taxonomy, its affinities, not about whether it was a modern human. As nearly as can be determined, the only ones to claim that any of Dr. Hurzeler's fossils are of modern-looking humans is Jochmans and those who endorse his book. However, if one can for a moment imagine this "evidence" from the creationist perspective, it is obvious that Jochmans made a tactical error. He has declared that a fossil jawbone of a possible progenitor of *Australopithecus* is definitely human. Therefore, if creationists maintain this position, they have absolutely no case for declaring that *Australopithecus* is not human.

Eocene Human Molar

An *in situ* human tooth in Eocene deposits would indeed be negative evidence for

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the current evolutionary time scale. According to Jochmans, such a tooth was found in November 1926 by Dr. J. C. F. Siegfriedt of Bearcreek, Montana, in "the Number Three shaft of the Mutual Coal Mine [actually it was the Eagle Mine] of Bear Creek . . . " in "an Eocene deposit dated at *30 million years old*" (1979:3). The deposit is, in fact, Paleocene, but this is a minor point.

Accounts of this remarkable fossil soon appeared in the popular press (*New York Times*, 1926; *Carbon County News*, 1926; *Literary Digest*, 1926). In 1927, Siegfriedt corresponded with Samuel Hubbard who published a description and photograph of the tooth (Hubbard, 1927). All accounts noted that the tooth was found in the Fort Union Formation and that Siegfriedt had several dentists confirm his opinion that the tooth was a human lower left second molar.

Hubbard (1927) and Jochmans (1979) had no doubts about the tooth being human. Neither author tells us, however, that another explanation was offered. In fact, the December 18, 1926, *Literary Digest* article, a publication from which Hubbard selectively quoted, carried this explanation.

The *Literary Digest* article is mostly a lengthy quote from Dr. E. E. Free who seemed to think that the tooth may really have been a human molar. However, Free said, "It would be premature to attempt, from the photographs alone, any decision as to whether or not this remarkable tooth is really human." He further noted that the tooth may have come from the condylarth *Tetraclaenodon*, which had teeth "remarkably similar in form to human teeth."

The Bear Creek fauna did not go unnoticed by paleontologists:

> The discovery of this fauna and its prompt announcement are due to Dr. J. C. F. Siegfriedt of Bear Creek, Montana. The first mammal tooth found, said to be a molar of *Tetraclaenodon* . . . received some attention in the press as it was at first believed to be a primate. [Simpson, 1928:1]

Siegfriedt sent his fossil collection to the American Museum "where it was cleaned from the stubborn matrix, cast, and photographed."

It seems more than curious that creationists never tire of pointing out "colossal ignorant blunders such as Nebraska man" (National Creation Conference, 1985), which was based upon a misidentified pig's tooth, yet feel that a single molar of humanlike form constitutes solid evidence for their view. It is a fact that the Fort Union Formation has yielded the remains of the condylarth *Tetraclaenodon* from the Crazy Mountain field and from Sweetgrass County, Montana, but no human remains have surfaced.

Triassic Shoe Sole

The "Triassic shoe sole," another "nail" in the coffin of evolution, gained notoriety

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in the August 13, 1922, issue of the *New York Times*. Later that year, the *American Weekly* (1922) carried a full-page story about the find and its subsequent investigation. Both articles say that John T. Reid, a mining engineer from Lovelock, Nevada, found the specimen. However, Hubbard (1927) reported that, in 1927, Reid corresponded with him and advised that the specimen was actually "found by Mr. Albert E. Knapp, near Fisher Canyon in Pershing County, Nevada." Reid did, however, take the specimen to New York where it was investigated at Columbia University, the American Museum of Natural History, and the Rockefeller Foundation.

Creationist writers (von Fange, 1981:32, 33; Jochmans, 1979:9) fully accept the "Triassic shoe sole" as evidence against evolution. The former actually discusses this specimen twice, once implying that it may be an extraordinary form taken by a false print (1981:32) and also reporting it as an actual fossil (1981:33). Apparently von Fange didn't look into the matter very far; his only source is Tomas (1971:24) who proposed that the "shoe print" was evidence for visits by ancient astronauts. Jochmans's (1979) source is Hubbard (1927) who has the facts reasonably straight, insofar as he reports them. However, it seems that Hubbard, Tomas, and all who followed have conveniently left out any mention of opinions contrary to their conclusions.

As noted above, Reid took the specimen to Columbia University and the American Museum of Natural History where the scientists "interpreted it as 'a remarkable natural imitation of an artificial object' " (Hattori, 1985:111). Reid also took the specimen to the Rockefeller Foundation where a "competent geologist" identified the limestone as Triassic (Hubbard, 1927). How this unnamed "competent geologist" determined that the limestone was Triassic is not specified, nor is his opinion, if he gave one, provided as to what the object might be. This same geologist apparently made microphotographs, which, according to Hubbard,

> . . . showed very clearly that it bore a minute resemblance to a well-made piece of leather, stitched by hand, and at one time worn by a human foot. The photographs showed the stitches very plainly; at one place it was double-stitched, and the twist of the thread could be clearly seen. The thread is smaller than any used by shoemakers today. [Hubbard, 1927:24]

Despite the negative opinions of scientists, Reid maintained that the microphotographs clearly demonstrated that the object was a shoe sole: "This feature cannot but be perfectly understood and plain to anyone who sees it, be he scientist or an ignorant, untutored savage" (*New York Times*, 1922b). In fact, Reid concluded that the microphotographs were so conclusive that only one interpretation was possible: ". . . which to all must be readily apparent, that this is the sole of a shoe and that it was surely done by the hand of man" (*New York Times*, 1922b). Two years later, Reid read a sworn affidavit to the congregation of Dr. John Roach

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Stranton's Calvary Baptist Church in New York, claiming that the American Museum "was biased in regard to evolution by not accepting the shoe sole fossil from the Triassic period" (*New York Times*, 1924a, 1924b).

There really is no complete answer in this case. As nearly as I can determine, the object is no longer available for study, so the evidence, as it were, comes down to the interpretation of Reid versus that of several scientists. Dr. James F. Kemp of Columbia University and professors H. F. Osborn, W. D. Matthew, and E. O. Hovey of the American Museum all "reached the same conclusion, in effect that 'it was the most remarkable natural imitation of an artificial object they had ever seen'" (Ballou, 1922). In fact, when I first saw the photograph of the "Triassic shoe sole," my immediate impression was that it is an example of of liesegang rings, which are bands or rings resulting from rhythmic chemical precipitation in fluid-saturated rocks.

Gobi Desert Ribbed Shoe Sole

Another "remarkable mantrack" is a "fossilized print of a shoe with a *ribbed sole*" (Jochmans, 1979:7). This "shoe print" was found in the Gobi Desert by a joint Chinese-Russian paleontological expedition, headed by Dr. Chou Ming Chen. A brief report of this "find" appeared in the popular Soviet magazine *Smena* (1961), Jochmans's only source:

> The find appears in sandstone dated at *15 million years*. Members of the expedition who carefully examined the shoe-print were quick to recognize that it was not the footmark of any animal, for the ribbing was too straight and regular to be of natural origin." [Jochmans, 1979:7]

The photograph in the *Smena* article is difficult to evaluate. It appears to show a rock several inches long upon which there are several evenly spaced parallel ridges. Between and at right angles to the ridges are smaller ridges. The poor quality of the photo makes it impossible to evaluate the object further.

Jochmans's illustration does not look much like the photo in *Smena* and, in fact, looks like flat-topped ripple marks. Flat-topped ripples are simply wave-formed ripples with their crests planed off by wavelets in shallow water (Tanner, 1958). As any geologist knows, wave-formed ripples can be remarkably straight and evenly spaced, especially over short distances.

In view of the evidence at hand, it is impossible to say what the object actually is. Apparently Dr. Chou, according to the *Smena* article, thought it was a foot-print, but (if we are to believe a popular magazine account) he attributed it to a cosmonaut who had visited earth long before the appearance of humans. The *Smena* photograph is, however, completely unconvincing—hardly the hard factual evidence

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that creationists claim demolishes the geologic time scale.

No further information is available on the Gobi Desert "ribbed shoe sole." The *Bibliography and Index of Geology Exclusive of North America* contains no entry indicating that Dr. Chou published anything on the 1959 Chinese-Russian expedition he reportedly headed. In fact, Colbert (1968) and Kielan-Jaworowska (1969) discuss the history of paleontologic exploration in the Gobi Desert, but neither mentions this expedition. There was, however, a brief item in the *New York Times* (1961) which mentioned dinosaurs found by a joint Chinese-Russian expedition into the Gobi Desert, but no further details were given.

Mesozoic Milk Teeth

This item is included because it demonstrates either a profound ignorance of the fossil record or a deliberate attempt to confuse the issue. "Mesozoic Milk Teeth" was a short item in the "Science and the Citizen" section of the December 1981 issue of *Scientific American*, which Brown claims shows that "the vertical sequencing of fossils is frequently not in the assumed evolutionary order" (Brown, 1983:211). In other words, more out-of-place fossils.

Perhaps one could argue that the *Scientific American* article carried an inappropriate title, since milk teeth were not discussed. It did, however, discuss Mesozoic mammal teeth and, particularly, a recent discovery in the Triassic-Jurassic Kayeta Formation of Arizona. But there is absolutely nothing in the article that even implies that any of the teeth were not in the correct order for evolution. The very first sentence of the article is the only passage that could have conceivably led Brown to his erroneous conclusion:

> The Age of Mammals is generally reckoned to begin at the end of the Mesozoic era . . . but the first known mammals actually appeared 120 million years earlier in the Mesozoic. . . .

Apparently, Brown's reasoning was that mammals should be found only in strata from the Age of Mammals and not in the preceding Age of Reptiles. But anyone with a basic understanding of paleontology knows that "Age of Mammals" is simply a term emphasizing the fact that mammals were the dominant terrestrial vertebrates during a particular part of geologic time. However, they were not the only terrestrial vertebrates during the Age of Mammals, nor were reptiles the only terrestrial vertebrates during the Age of Reptiles.

In short, there is nothing out-of-place about these fossils. It is true that Triassic mammals are not very common, but Mesozoic mammals in general have been known for decades.

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Five-toed Llamas

Von Fange states that "according to theory man evolved many millions of years after the last five-toed llama lived" (1981:31). He claims, however, that five-toed llamas are depicted on ancient pottery from the Tiahuanacan empire of South America and that skeletons of such llamas have been recovered from the ruins of this empire. He concludes that, since the Tiahaunacan empire cannot be millions of years old, five-toed llamas must have lived much more recently than paleontologists suppose.

Just how this "five-toed llama evidence" upsets the evolutionary applecart or geologic time scale is not clear, since at no time in their evolutionary history were llams, or any camel, five-toed. In fact, the earliest camel known, *Protylopus petersoni* of the late Eocene, was four-toed (Franklin, 1982), and by the Oligocene all camels were two-toed (Colbert, 1980). How von Fange concluded that "at a very early stage of their evolution" llamas had five toes is a mystery. He cites Colbert (1955:386) as his source, but nowhere does Colbert mention any camel with more than four toes.

On page thirty-one, von Fange illustrates a pot upon which five-toed llamas are depicted. The feet of one animal are shown, presumably the best, and it does appear that the left forefoot and hindfoot have five toes; the other feet don't show any toes. This seems like meager evidence at best. As Dr. Elizabeth Wing of the Florida State Museum says, "To question a time sequence based on a drawing on a pot does indeed seem like misplaced faith in the accuracy of the artist."

But what of the five-toed llama skeletons reportedly found in Tiahuanacan archeological sites? Von Fange's source is Honore (1964:164–165), but Honore cites no original source. He does note that Professor Tello discovered the skeletons around 1920. Tomas (1971:26) makes a similar claim. In 1929 and 1953, Verrill briefly mentioned Professor Tello's five-toed llamas, but he gave no original source either. Dr. Jane Wheeler of the University of Colorado advised that Professor Tello did not publish the results of all of his excavations, so the skeletons may actually exist, but added that she is not aware of them. In any case, documentation is lacking, and it is the responsibility of the writer—not the reader—to supply such documentation.

For the sake of argument, let us assume that five-toed llama skeletons actually were found as claimed. Creationists would still have to explain why this could not be a simple case of polydactyly. While it is true that no five-toed polydactyl camels are known, examples of four-toed alpacas, although rare, are known (*see* Fernandez-Baca, 1971).

Piri Re'is Map

The Piri Re'is map, which dates from the early 1500s, is a favorite among those

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who argue for ancient astronauts (for example, von Daniken, 1969)—the claim being that the map is so accurate that it must have been made from aerial photographs. Von Fange (1981:1) doesn't argue for ancient astronauts, but he does claim that the map "shows amazing knowledge and accuracy." He also contends that it shows Antarctica without its ice cover and that it was copied "from a number of now lost ancient originals which existed long before the time of the Greeks." Von Fange takes this to mean that the Antarctic ice cap is rather recent, not millions of years old as claimed by conventional geologists.

Debunking this bit of pseudoscientific mythology is like beating a dead horse since the facts are well known (*see* Story, 1976; Stiebing, 1984). In fact, Wilson in *Crash Go the Chariots* (1972), a book advertised by the Institute for Creation Research and the Bible-Science Association, thoroughly debunks the Piri Re'is map myth. The January 1985 Bible-Science Association booklet, *Creationism Resources*, says that Wilson's book is "an enlarged edition showing the fallacies of Von Daniken's 'Chariots of the Gods' concept."

One of the fallacies Wilson exposes is the "accuracy" and, by implication, "amazing knowledge" shown by the map. Even von Fange's own source (Hapgood, 1966) pointed out a number of obvious errors in the map. (Hapgood nevertheless thought the map showed the work of an ancient civilization.) Stiebing comments on the map's accuracy:

> The Caribbean area on the . . . map bears little resemblance to reality. Cuba is wrongly labeled "Hispaniola" and is drawn totally out of proportion. The Virgin Islands are shown in the wrong positions, incorrectly shaped and badly out of scale. The eastern coast of South America is also represented incorrectly; the Amazon River appears twice, nine hundred miles of coastline are omitted, and there is no sea passage shown between South America and Antarctica. [1984:92]

The Piri Re'is map is not amazingly accurate, but it is not a bad map—for the sixteenth century. "The Piri Reis [*sic*] work is highly creditable, being a painstaking attempt to correct the known efforts of the cartographers before him" (Wilson, 1972:77). Both Wilson and Stiebing note that Piri Re'is himself stated on the map, in a marginal note, that it was compiled from older maps and charts. In any case, the map does not support von Fange's assertion that the Antarctic ice cap is recent in origin.

Washington Artifacts

Human artifacts found under a glacial moraine in Washington state? Apparently this is considered by creationists as more evidence that has been "ignored or ex-

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plained away by the 'scientific community' " because it does "not readily fit into an evolutionary framework" (Johannsen, 1984:11). However, an examination of the facts reveals two things: the credulity of some creationists and the creationists' abuse of source materials. According to von Fange:

> In the museum at Moses Lake, Washington, are some very crude scrapers on exhibit which *were* found under a glacial moraine. This would appear to date man in Washington to a time *before the Pleistocene* epoch, which scientists are reluctant to do. . . . [1981:28; emphasis added]

The reluctance of scientists is understandable if one considers the statement of von Fange's source in its entirety:

> This museum houses a large number of artifacts collected by Adam East along the Middle Columbia River. Detailed information about these finds is often lacking, but many of them were made by Salish Indians and their prehistoric predecessors.
>
> Some very crude scrapers on exhibit are *said* to have come from under a moraine. Since a moraine is a mass of rock and gravel deposited by a glacier, these tools would be evidence of man's presence in the area *before the last glacier of the Ice Age.* Scientists are not sure with what care the scrapers were excavated and are cautious about accepting them as proof that man existed in America in preglacial times. [Folsom, 1971:70; emphasis added]

It is apparent that Folsom's meaning has been not-so-subtly altered and relevant data has simply been omitted. But even if the artifacts "were found under a glacial moraine," why would that necessarily imply pre-Pleistocene human occupation of Washington? It is well known that a lobe of the continental ice sheet extended well into Washington as recently as 15,000 years ago and that the ice sheet did not completely retreat from that state until less than 12,000 years ago.

"Impossible" Fossils of Europe

Von Fange claims that "Heizer notes a number of impossibilities according to commonly accepted geologic dating" (1981:28). These impossible fossils show the marks of human activities and include "a hyena tooth sawn by a flint, cutting operations on the fossilized bone of an extinct rhinoceros and on other animals at a site near Paris, and evidence of the use of a sharp tool on the horn of a rhino in Ireland." Just what is "impossible" about these fossils is not specified. Perhaps the fact that the animals noted above are extinct in Europe leads von Fange to the erroneous conclusion that they could not have coexisted with humans.

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Heizer (1962) never implied that any of these fossils were "impossibilities." What he did was reproduce an early nineteenth-century letter from Edward Lartet to the president of the Geological Society of London. This letter, and others produced by Heizer (1962:61–105), contain evidence for the coexistence of humans and now-extinct animals in Europe. There was initially some question of fraud, especially concerning some of the human artifacts, but subsequent work showed the fossils and artifacts to be genuine. At that time, human antiquity in Europe was poorly known, but these fossils and artifacts constitute some of the evidence that solved that particular problem.

Either von Fange is appealing to the credulity of his intended reading audience or he is simply unaware of the facts. In any case, there is nothing "impossible" about these fossils; they were found in Pleistocene strata and demonstrated the coexistence of humans with hyenas, rhinos, and so forth, in Europe.

Conclusions

Creationists commonly portray themselves as serious researchers whose evidence and views are ruthlessly opposed by an unyielding scientific orthodoxy. Opposition is real enough—but not because the scientific community is unwilling to evaluate legitimate evidence. The problem is that much of the creationist "evidence" is not only scientifically unsound but sometimes just plain silly. One can only wonder how some of this "evidence" could be taken seriously by anyone.

Scientists are ridiculed for making a mistake which they later correct (for example, Nebraska Man was called a "colossal ignorant blunder"), yet creationists use exactly analogous "evidence" to support their position. To creationists, the "Eocene human molar" *is* a human tooth; no other interpretation is mentioned nor is the evidence which invalidates the creationist position even brought up. The "Miocene human jawbone" *is* proclaimed by creationists to be without a doubt that of a modern-looking human, even though Jochmans's only cited source made no such claim and I can find no other source to support it. The "five-toed llama" argument is undocumented and, even if true, is irrelevant.

Scientists and creationists alike consider the works of Erich von Daniken to be pseudoscientific. But von Fange uses a typical von Daniken approach to the Piri Re'is map by omitting well-known relevant data. The "Washington artifacts" and "impossible fossils of Europe" demonstrate reasoning that can only be attributed to a zeal which compels one to grasp at any "evidence" that superficially seems to support the creationist position irrespective of evidence to the contrary.

So, the evidence for creation reviewed in this article does not stand up to critical scrutiny. Nevertheless, this same "evidence" will no doubt continue to appear in creationist literature as if once having been asserted as fact it is inviolate. To question these "facts" is, in creationist circles, to "explain away" the evidence—not

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because the evidence is faulty but because scientists are unyieldingly committed to the "doctrine of evolution." Creationists are, however, correct on one point: some of their "evidence" is, indeed, largely ignored. But why should out-of-context quotes, distortions, and undocumented claims be considered evidence in the first place?

Acknowledgements

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Letters to the Editor

Walter Brown is a clever and persuasive writer, but he is lavishly wrong on some points ("A Second Response to Jim Lippard," *Creation/Evolution* XXVI). I would like to mention three.

First, the cerebral spare tire myth. The notion that humans use only a "small fraction" of their minds' potential (p. 39) has been canonized in the media and promulgated endlessly by some pop psychologists and systems, such as EST, Scientology, and the Dale Carnegie courses. But don't believe it. Barry Beyerstein, in his incisive article in the *Skeptical Inquirer* (12:2:170–171), tries to trace the origin of this particular urban myth. It may go back to misinterpretations of neural research in the 1930s which showed that, in the more and more complex species, progressively smaller fractions of the cortex are tied to strictly sensory-motor functions. The other portions, which are sometimes called the "silent cortex," are not silent at all but lively with activity of other sorts. In humans, for example, evidence indicates that they are responsible for characteristics such as language, intuition, and abstract thought.

Next, the missing neutrinos (p. 46). The low neutrino output of the sun used to be an interesting problem, but astrophysicists have had a feasible solution since 1986, when calculations by Hans Bethe showed that solar interactions would change many of the electron neutrinos into muon neutrinos. Since our neutrino detectors can detect only the electron neutrinos, it's no mystery that we see only a fraction of the number we originally expected. For details, see the article "Hans Bethe on Solar Neutrinos" by John Maddox in *Nature* (1986:320:677).

Finally, *Archeopteryx* (*Creation/Evolution* XXVI:47). As I understand it, the authenticity of the two textbook fossils is proven by exactly matching hairline cracks and dendrites on the feathered areas of the opposing slabs, which show the total absence of an artificial cement layer into which feathers could have been pressed by a forger. Please see the article "*Archeopteryx* Is Not a Forgery" by Alan J. Charig et al. in *Science* (1986:232:622). Also, I understand that a recently discovered *Archeopteryx* fossil from Germany shows delicate feather impressions *under* the wing bones, which could not be possible to forge. For details, see the discussion in the January 1989 issue of *Discover.*

In any case, Brown seems to misunderstand the significance of *Archeopteryx*. Right after disputing the feather impressions, he makes much of the discovery of some older birdlike fossils, as if this disproves its transitional status.

It doesn't. Of course, a lack of

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consensus exists about the precise lineage of *Archaeopteryx*. For good reason, paleontologists and taxonomists argue whether it was a direct ancestor of modern birds or a collateral ancestor (a great uncle); they may even disagree whether it was a direct descendant of dinosaurs or a close cousin. Some intriguing evidence, such as those older fossils, supports the "cousin-uncle" hypothesis. This is what makes science exciting.

But none of this even suggests *Archeopteryx* is nontransitional. The fact remains that it has many salient reptilian features and many avian features—too many to call coincidence. Slightly younger bird fossils (*archaeornis*, *ichthyornis*, and *hesperornis*) and slightly older ones (*protoavis*) also have reptilian features that would be highly unusual in modern birds. In brief, *all* primitive birds seem to have such features, and modern birds *do not* —at least not to the same degree (especially flying birds). *There is your pattern*. Our friend *Archeopteryx* is merely a good example.

Why does *Archeopteryx* have to be directly ancestral to modern birds in order to be a transition? Creationists typically seem to misunderstand the meaning of *transitional* in taxonomic science. I was taught that a transitional form is one that shows morphological-genetic traits connecting two distinct groups. To my knowledge, biologists never insist that the "intermediate form" must fall on a direct line of ancestry. Typical transitions are *chimeras* or mosaics, combining significant characteristics (and patterns of characteristics) from the two groups. *Archeopteryx* does this. And besides *Archeopteryx*, we have the ichthyostega, which link fish to amphibians; we have the seymouria, which link amphibians to primitive reptiles; and we have the therapsids, which demonstrate a transition from reptiles to mammals. (In fact, this last fossil bridge is so continuous that researchers still dispute where one class leaves off and the other begins.) Many of these are "just" mosaics. Still, they are transitions.

I also wondered why Brown is even attempting to debunk the feather impressions and the bird-lineage of *Archeopteryx*. Most of the heavy-hitter creationists, such as Henry Morris (*Scientific Creationism*, 1974:84–85) and Duane Gish (*Evolution: the Fossils Say NO!* 1978:82) rather baldly insist that *Archeopteryx* is "100 percent bird"; they deny or deprecate the reptilian features and try to magnify the avian. You would think that Brown would want to help *them*. Instead, he tries to give us ammunition.

This is serious. I suggest that *Creation/Evolution* suspend the debate between Walter Brown and Jim Lippard until the creationists can get their debate platform in sync. Once that's decided, we can return to more trivial issues.

Kenneth E. Nahigian

I wish to address two items in the debate between Jim Lippard and Dr. Walter Brown (*Creation/Evolution* XXV) that I feel need clarification.

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The first involves Brown's category number sixty-three as described by Lippard—that being "Out-of-Order Human Artifacts," which discusses the infamous Ordivician hammer of the Reverend Carl Baugh, which Baugh claims was found in the rock strata many millions of years old. A simple way to settle this entire controversy would be to have the hammer radiocarbon dated, but, as Lippard says, Baugh has consistently refused to allow this. Brown takes exception to this, explaining that "Baugh assured me four years ago . . . that he would like to have the wooden handle of his hammer radiocarbon dated," and then lists three of what Brown calls "understandable" stipulations of the dating process: (1) that Baugh accompany the hammer throughout the testing process; (2) that the hammer be dated by accelerator mass spectrometry, in order to conserve wood; and (3) that some outsider pay for the entire cost of the dating.

Regarding the first stipulation, I fail to understand why any reputable lab would refuse to allow Baugh to accompany the hammer during the tests; thus, Baugh's first stipulation is rather meaningless. Surely, Baugh is not suggesting that someone will try to pull a fast one on him when his back is turned. Or is he? What is the problem here?

Secondly, if Baugh wishes to employ a particular dating technique, again I fail to see a problem. He is free to choose any technique he wishes, as I am sure there are an adequate number of labs equipped for this which would be willing to tackle the job. If Baugh can't find one, I imagine one of *Creation/Evolution*'s readers would be happy to point one out to him.

Baugh's final stipulation—that someone else pick up the tab—and Brown's obvious agreement with him makes it painfully clear that neither of these two have the slightest understanding of the process of scientific experimentation and verification. If I, as an academic, claim to have made a remarkable discovery, it is not unreasonable to suggest that I have an obligation to furnish the supporting evidence, including, if necessary, the time and money required for proof. What leads Baugh to believe he has the right to ask others to pay for his research? Quite simply, Baugh discovered the hammer; Baugh made the remarkable claims for it; therefore, let Baugh do his own work and not ask others to do it for him. Far from being "understandable," Baugh's stipulations seem to be little short of evasive tactics.

A final note on this seems appropriate. Brown mentions that Baugh assured him "four years ago" that he would like to have the hammer dated. If four years have gone by and nothing has happened, I think it is safe to conclude that Baugh has no interest whatsoever in determining the truth about his marvelous hammer.

My second comment involves a point Lippard raised in his article, which I feel may have not been adequately emphasized—a point which demonstrates Brown's callous disregard for thorough investigation. In a letter to Brown dated January 6, 1987, Lippard responds to points ninety-

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seven through 112 of Brown's book, which describe allegedly unexplained geological phenomena. Lippard's criticism of these points, which I quote here in its entirety is:

> 97–112. Mike Lacey, an ASU geology graduate student, assures me that none of these phenomena are the least bit "unexplained," they are well-understood phenomena.

Note well that Lippard rejects a full sixteen of Brown's points by simply stating that there are well-known explanations for all of them. Yet, Brown's response to this (printed in full at the beginning of Lippard's article) is to dismiss Lippard's rejections *without even asking what these explanations might be!* And this from someone who, in his conclusion, suggests that "each reader can judge Lippard's accuracy, competency, and thoroughness."

Since Brown made no attempt whatsoever to respond to this point in his first rebuttal, I am interested whether he makes the effort to address it in succeeding ones. Enquiring minds want to know.

R. P. J. Day

In "A Challenge to Creationists" (*Creation/Evolution* XVII), you suggest two possible bases for the creationists' second law of thermodynamics argument. I would like to suggest a third.

I have always been puzzled by the creationist second law of thermodynamics arguments against evolution, since organisms are open systems that continually battle entropy by taking in energy in one form or another. Morris states, "Creationists are puzzled as to why evolutionists give so little attention to the [second law of thermodynamics] problem" (*Scientific Creationism*, 1974). He goes on to discuss evolution and thermodynamics and says, "Now the question again is, not whether there is enough energy reaching the earth from the sun to support evolution, but rather *how* this energy is converted into evolution? The evolutionary process, if it exists, is by far the greatest growth process of all."

The creationist view of the universe is a mystical one and they may assume, quite unconsciously, that scientists view evolution as a mystical force that is greater than the sum of its parts—that scientists are proposing that evolution is something akin to a creator which directs the changes which we call evolution.

Morris continues, "Thus neither mutation nor natural selection is either a directing program or an energy converter."

Creationists do not seem to understand that what scientists call evolution is the result of reproduction and natural selection and that the only energy needed is the energy used by individual organisms for growth, development, reproduction, food acquisition, and so forth. The reason this argument has continued for so long might be due to the creationists' erroneous perception of evolution as an energy-using, directing force.

William B. Peet, Jr.

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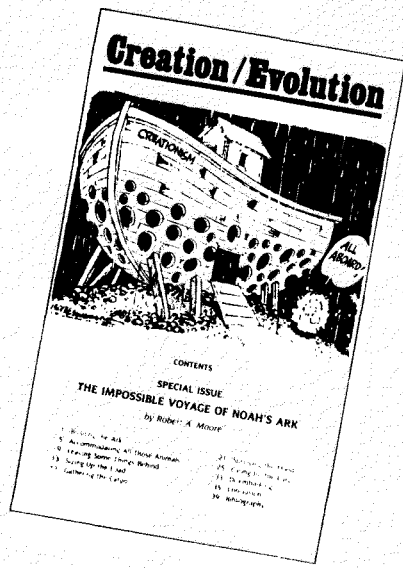

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